SYSTEM FOR DETERMINING THE CARBON DIOXIDE CONTENT OF EXHALED BREATHING AIR

[Specification]

BACKGROUND OF THE INVENTION

This application claims the priority of 198 31 022.6, filed July 10, 1998, and PCT/EP99/04849, filed July 9, 1999, the disclosure of which is expressly incorporated by reference herein.

The present invention relates to a system for determining the carbon dioxide content of exhaled air, having a sensor to which the exhaled air is supplied in an analysis duct for generating measuring signals proportional to the carbon dioxide content, and having an evaluation device which is connected to the sensor and has indicating devices.

It is known to use such a system in capnography. In this case, [by means of] a sensor constructed particularly as an infrared analyzer[,] determines and records the carbon dioxide content of the exhaled air[is determined and recorded]. During a main flow process, the entire exhaled air, which flows in a main flow tube with a fitted-on sensor, is analyzed. The sensor signals are supplied to an evaluation and indicating instrument. In a secondary flow process, a portion of the exhaled air is taken by [means of] an air tube or a respirator tube from the nostrils by [means of] a vacuum, such as a pump, and is supplied to a sensor contained in the evaluation and recording instrument. In this [case] apparatus, a relatively long air-conducting path is required for the exhaled air. A relatively large dead volume, which is

susceptible to contamination and blockage and from which the exhaled air is taken, occurs between the patient's nasal cavities and the sensor which carries out the analysis with respect to the CO_2 content.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a carbon dioxide analyzing system [of the initially mentioned type,] in which precise measuring results are obtained at low expenditures.

According to the invention, this object [is] has been achieved [in that] by an air tube, which supplies the exhaled air, is connected to one end of the analysis duct, [in which case] such that the exhaled air is acted upon only by [means of] the pressure causing the characteristic flow in the air tube and the analysis duct, [and in that] the analysis duct [is] being open at its other end.

The air tube is preferably connected with the interior of a mask surrounding the mouth and the nose. For achieving a small dead volume, the air tube and the analysis duct are preferably exchangeably fastened to the mask by [means of] a mask adapter. In this [case] novel apparatus, the analysis duct can be arranged in a sensor adapter which is detachably connected with the mask adapter. The sensor may also be detachably fastened to the sensor adapter.

Oxygen can be supplied to the mask interior by way of a probe. An opening for excess oxygen may be provided in the probe, so that the measuring results are not impaired. In addition, openings for a gas exchange between the mask interior and the outside air can be provided in the mask.

By [means] way of the mask, exhaled nasal as well as oral air can in each case be evaluated individually or jointly for the measurement.

In addition, [by means of] the present invention[,] achieves a system [of the initially mentioned type can be provided] in which the distance between the nostrils, from which the exhaled air is taken, and the sensor is [short] shortened.

As a result, it is further achieved that the sensor and the air tubes, which are guided to the sensor and can be placed in the nostrils, can be fastened to an adapter which can be fixed on the patient's nose.

In a currently preferred manner, the sensor can be fixed by [means of] the adapter over the bridge of the nose, the two air tubes being guided to a joint analysis duct for carrying out the CO_2 analysis by [means] way of the sensor. The cross-section of the analysis duct preferably corresponds approximately to the sum of the two cross-sections of the air tubes. [In] Also in a preferred manner, the diameters of the two air tubes are significantly smaller than the diameters of the two nostrils into which the tube ends of the air tubes are inserted. The total

volume, which is composed of the volumes of the two air tubes and of the analysis duct of the sensor, is also significantly lower than the two volumes of the nasal cavities.

[As a result of this arrangement, because] Because of the extremely short transmission route of the exhaled air from the nostrils to the sensor, the arrangement achieves a measuring precision [can be achieved] for the secondary flow process which is as high as that of the main flow process. Because of the small dead volume in the air tubes, which are preferably joined in front of the sensor, the arrangement becomes insensitive to contamination and blockage. For cleaning the air tubes, water filters and water catches and pumps for removing contamination and blockages are not required. A disturbance-free measurement can therefore be carried out at low expenditures. The connection between the sensor and the evaluation and indicating instrument takes place by [means of] an electric cable which transmits the measuring signals supplied by the sensor. This transmission route can be selected arbitrarily. This results in a simple and clear implementation of the measuring operation, particularly in a secondary flow application during capnography.

A receiving device, into which the sensor can be detachably inserted, can be provided on the adapter. As a result, the same sensor, which is connected or can be connected with the evaluation and indicating device, can be used for the main flow process as well as for the secondary flow process.

Two fixing legs, which are connected with one another in an articulated manner and can be fixed on the nose at both sides of the bridge of the nose, can be provided for the adapter. The fixing legs can preferably be provided with adhesive surfaces, so that the adapter can be glued to the skin of the nose in the manner of a plaster (for example, a snoring patch). In the glued-on condition, the fixing legs can be subjected to tension, by which an expanding prestress is exercised on the sides of the nose or the walls of the nostrils, thereby facilitating breathing.

In addition, at least one of the two air tubes can be constructed such that a probe, particularly an O_2 probe, can be inserted into the air tube in such a manner that the supply of exhaled air to the sensor is interrupted. For this purpose, the probe can be inserted into the air tube in an alignment with the tube end which is inserted into the nostril and extends essentially in a straight line. It is also possible that the inserted probe extends completely or partially through the tube end inserted into the nostril. For this purpose, a corresponding perforation can be provided on the air tube which consists particularly of a flexible material (e.g., a hose material). In this case, oxygen can be introduced by way of the probe into one of the two nostrils, while the CO_2 measurement of the exhaled air continues to take place by way of the other nostril.

BRIEF DESCRIPTION OF THE DRAWINGS

[The invention will be explained in greater detail by means of the figures.]

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

Figure 1 is a view of an embodiment of the present invention from a viewing direction into the nostrils;

Figure 2 is a top view of the embodiment of Figure 1;

Figure 3 is a perspective [representation] view of a detail marked A in Figure 1 on a tube end of an air tube; and

Figure 4 is a view of another embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The embodiment illustrated in Figures 1 to 3 has a sensor 6 which is connected by [means of] an electric cable 13 to an evaluation and indicating device 12. The sensor 6 can be inserted into a receiving device 1 which is fastened to an adapter 7. In addition to the receiving device 1 for the sensor 6, an air supply to an analysis duct 8, which can be preformed in the holding device 1, is fastened on the adapter 7.

The air supply consists of two air tubes 5 which can be inserted into nostrils by [means] way of their tube ends 10. At the tube ends 10, which can be inserted into the nostrils, the air tubes 5 have holding devices 4 whose shape is adapted to the nostrils. The holding devices 4 have the shape of fitting pieces which can be inserted into the nostrils in an essentially form-locking manner. The holding devices 4 in the form of open adjusting rings ensure that the tube ends 10 inserted into the nostrils are held in an area in the proximity of the tip of the nose. As a result, possibly existing secretions in the nose of the reclining patient can emerge unhindered without blocking the air tube ends 10. The holding devices 4 may be constructed in the form of elastic spreader clamps. This causes a desirable widening of the nostril. Because the inlet openings at the tube ends 10 are much smaller than the cross-sections of the nostrils, breathing is barely impaired.

The tube ends 10 inserted into the nostrils extend essentially in a straight line. These tube ends 10 are adjoined by curved tube parts 15 which change into two tube parts extending toward one another essentially in a V- or U-shape. In front of the inlet into the holding device or into the analysis duct 8 of the sensor 6, the two air tubes 5, as illustrated particularly in Figure 2, are guided together. The analysis duct 8 is open at its other end 26.

The sensor 6 can be constructed in a known manner, [in which case] such as a miniaturized system [can be used]. The air tubes

5 preferably consist of flexible hoses.

The adapter 7 has two fixing legs 9 which are connected with one another in an articulated manner. In the illustrated embodiment, the fixing legs 9 have adhesive surfaces 3 constructed in the form of adhesive strips. The adapter 7 also has a connection strip 16 situated between the two fixing legs 9. The receiving device 1 for the insertible sensor 6 can be fastened on this connection strip 16. The two fixing legs 9 are connected with the connection strip 16 by way of preferably elastic hinges 2. When the adapter 7 is glued onto the exterior surface of the nose, the holding device 1 is situated over the bridge of the nose. Because of the spring effect of the two hinges 2, the two fixing legs 9 are pressed toward the outside so that the sides of the nose and therefore the nasal cavities are expanded for [a] better breathing. [By means of the] The flexible construction of the air tubes 5 and of the adapter 7[,] achieve a high degree of adaptation [is achieved] to different nose sizes, so that only a small number of different adapter sizes must be kept ready.

As illustrated particularly in Figure 3, a perforation 14, which is provided at the end of the curved tube piece 15, can be penetrated by a probe 11 in both air tubes 5 or at least in one of the two air tubes 5. When the probe 11 is inserted in its axial direction into one of the two air tubes 5, the probe 11, [in its axial direction,] is in an alignment with the axial direction of the respective tube end 10 which is inserted into the nostril, as

illustrated in Figure 3. In this case, the supply of exhaled air toward the sensor 6 is interrupted[. In this manner,] and oxygen can be fed through the probe 11[, in which case]. Thereby the CO_2 measurement of the exhaled air fed to the sensor by way of the other air tube 5 can simultaneously be carried out.

In the embodiment illustrated in Figure 4, a mask 19 is provided which can be placed over the mouth and the nose. An air tube 7 guided to the analysis duct 8 is situated in a mask adapter 21. By [means] way of a ring opening, the mask adapter 21 is pushed over a downward-pointing extension piece 27 of the mask 19. A probe 20 for a supply of oxygen can be inserted into the extension piece 27.

The air tube 17 is guided around the extension piece 27 in the mask adapter 21 and is connected with two inlet openings 24, [and] 25 which are provided in the mask 19. By way of the inlet openings 24, [and] 25, a fluidic connection is established between a mask interior 18 and the air tube 17. When the mask 19 is placed, the inlet opening 24 is aligned with the patient's nostrils, and the inlet opening 25 is aligned approximately with the patient's mouth. From the inlet openings 24, [and] 25, separate hose-shaped connections can extend to the mouth and the nose.

In addition, openings 23 are provided on the two side walls of the mask 19 and permit a gas exchange between the mask interior 18 and the outside air.

The sensor adapter 7, on whose receiving device 1 the sensor

6 is detachably fitted, can be pushed onto the mask adapter 21 such that the air tube 17 leads into the analysis duct 8. The connection between the air tube 17 and the analysis duct 8 takes place at one end of the analysis duct 8. At its other end 26, the analysis duct 8 is open and leads into the outside air.

In the probe 20, an opening 22 is provided in the area of its connection piece 28 with the mask 19. The opening 22 is open toward the outside and ensures an exiting of excess oxygen [into] to the outside air. For this purpose, the outlet opening 22 is situated below the edge of the extension piece 27, in which the connection piece 28 of the probe 20 is inserted into the mask 19.

During the exhaling process, the exhaled air [has a] pressure [causing] causes the characteristic flow by which excess oxygen is displaced toward the outside through the opening 22. The oxygen supplied into the mask interior 18 by way of the probe 20 can be acted upon by a corresponding pressure so that no impairment of the CO_2 measurement occurs in the exhaled air. Through the inlet openings 24, [and] 25, sufficient exhaled air arrives in the air tube 17 for the measurement to be carried out in the analysis duct 8. As a result of corresponding connections between the respective inlet opening 24, [and] 25 with the nose and the mouth, a separate nasal or oral evaluation of the exhaled air can also be carried out.

The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.

[List of Reference Numbers

1	Receiving device
2	hinge
3	adhesive surfaces
4	holding devices
5	air tube
6	sensor
7	adapter
8	analysis duct
9	fixing leg
10	tube end
11	probe
12	evaluation and indicating device
13	electric cable
14	perforation
15	tube piece
16	connection strip
17	air tube
18	mask interior
19	mask
20	probe
21	mask adapter
22	opening
23	opening

	24	inlet opening
	25	inlet opening
	26	open end
	27	extension piece
5	28	connection piece]

ATTACHMENT

[1]22. System for determining the carbon dioxide[(CO_2)] content of exhaled air, [having] comprising a sensor to which the exhaled air is supplied in an analysis duct for generating measuring signals proportional to [the] carbon dioxide content, [and having] an evaluation device which is connected to the sensor and has indicating devices,
[characterized in that] an air tube [(5; 17)], which supplies the exhaled air, is operatively connected to one end of the analysis duct [(8), in which case] such that the exhaled air is acted upon only by [means of the] a pressure causing [the] characteristic flow in the air tube [(17)] and the analysis duct[(8)], [and in that] the analysis duct[(8) is] being open at its other end[(26)].

[2]23. System according to Claim [1]23, wherein
[characterized in that] the air tube [(17)] is connected with [the] an interior portion [(18)] of a mask [(19)] surrounding [the] a patient's mouth and [the] nose.

[3]24. System according to Claim [1 or 2]22, wherein
[characterized in that] a mask adapter [(21), which] is configured to receive[s] the air tube [(17) carrying the exhaled air], and is exchangeably fastened on the mask[(19)].

[4]25. System according to [one of Claims 1 to 3]Claim 24, wherein

[characterized in that] the analysis duct [(8)] is arranged in a sensor adapter [(7)] which is detachably connected with the mask adapter[(21)].

[5]26. System according to [one of Claims 1 to 4]Claim 22, wherein

[characterized in that] a probe oxygen [can be supplied to] is provided to supply the mask interior[(18) by way of a probe (20)].

[6]27. System according to Claim [5]26, wherein

[characterized in that] an excess oxygen opening[(22) for excess oxygen]is provided in the probe[(20)].

[7]28. System according to [one of Claims 2 to 6]Claim 23, wherein

[characterized in that] openings [(23)] are provided in the mask for [a] gas exchange between the mask interior [(18)] and [the] outside air[are provided in the mask (19)].

[8]29. System according to Claim [1]22, wherein

[characterized in that] breathing air exhaled through the patient's nose is supplied to the sensor [(6)] by [means of] air tubes [(5)] inserted in the patient's nasal cavities, and [in that] the sensor

[(6)] and the air tubes [(5) can be fastened or are fastened] are fastenable to a sensor adapter [(7) which can be fixed] fixable on the patient's nose.

[9]30. System according to Claim [8]29, wherein [characterized in that] the sensor [(6) can be fixed] is fixable by [means of] the sensor adapter [(7)] over the bridge of the patient's nose, and the two air tubes [(5)] are guided to the analysis duct[(8)].

[10]31. System according to Claim [8 or 9]Claim 29, wherein [characterized in that] the two air tubes [(5)] are guided together in front of the sensor[(6)].

32. System according to Claim 31, wherein the sensor is fixable by the sensor adapter over the bridge of the patient's nose, and the two air tubes are guided to the analysis duct.

[11]33. System according to [one of Claims 1 to 10]Claim22, wherein
[characterized in that] the adapter [(7)] has a receiving device [(1)] for the sensor [(6)].

[12]34. System according to Claim [11]33,wherein [characterized in that] the sensor [(6) can be] is detachably [inserted] insertable in the receiving device[(1)].

[13]35. System according to [one of Claims 8 to 10]Claim 29, wherein

[characterized in that] the sensor adapter [(7)] has two fixing legs [(9) which are] articulatably connected [in an articulated manner] and [can be fixed] fixable at both sides [of] on the bridge of the patient's nose[on the nose].

[14]36. System according to [one of Claims 8 to 13]Claim 35, wherein

[characterized in that] the sensor adapter [(7) can be glued] is glueable on the skin of the patient's nose.

[15]37. System according to Claim [13 or 14]36, wherein

[characterized in that, when the fixing legs (9) are glued onto the skin of the nose,] the fixing legs are [subjected] subjectable to a tension which widens the patient's nasal cavities when the fixing legs are glued onto the skin of the patient's nose.

[16]38. System according to [one of Claims 8 to 10]Claim29, wherein

[characterized in that] the air tubes [(5) consist] are comprised of flexible material.

[17]39. System according to [one of Claims 8 to 16]Claim 29, wherein

[characterized in that the] a respective tube end [(10)] of the air tube [(5)] inserted into a patient's nostril [can be fixed in the nostril] is fixable thereon by [means of] a holding device [(4), which is] adapted to the shape of the nostril.

[18]40. System according to Claim [17]39, wherein [characterized in that] the respective tube end [(10)] is fastened to the holding device[(4) such that it is] so as to be held in an area of the nostril adjacent to the tip of the patient's nose.

[19]41. System according to [one of Claims 1 to 11]Claim 41, wherein
[characterized in that] a probe [(11) can be inserted] is insertable from [the] outside into at least one of the air tubes [(5), such that the] to interrupt a supply of exhaled air to the sensor[(6) is interrupted].

[20]42. System according to Claim [19]41, wherein [characterized in that] the probe [(11)] is one of aligned with [the] a tube end [(10)] inserted in the patient's nasal cavity [or is] and at least partially inserted into [this] the tube end[(10)].

[21]43. System according to Claim [19 or 20]41, wherein [characterized in that] the probe [(11)] is an oxygen probe.